Nuclear Experimental Physics Group I(Annual Report)

journal or publication title	The science reports of the Tohoku University. Ser. 8, Physics and astronomy
volume	6
number	2
page range	67-72
year	1985-08-25
URL	http://hdl.handle.net/10097/25557

Nuclear Experimental Physics Group I

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Research Activities

(I) LIGHT ION NUCLEAR PHYSICS

a. A Systematic Study of the LEOR Strength in Sm Isotopes (T. Tohei, J.I. Hirota, T. Nakagawa, T. Saito, Y. Fujii, Y. Hozumi and M.H. Tanaka)

The energy distributions of the observed EWSR strengths are in good agreement with the RPA calculations except for lower-lying states. But, the variation of the observed weighted mean energies for the LEOR could not be reproduced by the RPA calculations in which the energies are still kept to a constant for all the isotopes. Calculated EWSR strengths up to $E_x = 10$ MeV with ~ 20 % fraction for the deformed Sm isotopes are also in good agreement with corresponding experimental values. In the case of ^{144}Sm, however, the calculated EWSR is smaller than the observed one because the coupling parameter has been taken to be 0.7. The calculated distributions for the $K = 0$, 1, 2, 3 components are similar to each other in ^{150}Sm.

In conclusion, the detailed strength distribution of the 3^- states in the Sm isotopes and the splitting of the LEOR strength in ^{150}, ^{152}Sm as well as in ^{154}Sm were first observed systematically in this experiment. The splitting of the LEOR strengths as well as the decrease of the excitation energy might arise from the coupling of the LEOR to the quadrupole deformation. As a result of the RPA calculations, it is shown that the splitting of the LEOR strength has appeared as the result of the competition of the many K components.

b. Excitation of $T = 1$ Stretched 6^- States in ^{40}Ca by Inelastic Proton Scattering (T. Saito, Y. Hozumi, T. Tohei, T. Nakagawa, A. Sato, M. Fujioka and Y. Fujita)

In order to study of stretched high spin states a high resolution ^{40}Ca(p,

p') experiment has been performed using the 65 MeV proton beam from the RCNP cyclotron with the high resolution spectrograph "RAIDEN". The angular distributions of protons were measured in the angular range from 10° to 85° for the excitation energy from 12 MeV to 16 MeV. The peaks at 13.91 MeV, 14.00 MeV and 14.28 MeV are relatively strong in the large angle in this present (p, p') scattering. The calculated angular distribution using a M3Y interaction reproduces the experimental data well. From those results in both electron and proton experiments the 14.28 MeV state is assigned as the $T = 1$, 6^- state. Detailed analysis of the angular distributions are in progress.

c. Nuclear Spectroscopy in sd-Shell Nuclei through a (d, n) Reaction (T. Tohei, T. Nakagawa, K. Furukawa, T. Kawamura, M. Kabasawa, Y. Takahashi, A. Sato, T. Ishimatsu, H. Orihara, K. Miura and H. Ohnuma)

Measurements of angular distribution for (d, n) reactions on ^{25}Mg, ^{28}Si, and ^{40}Ca have been done by the TOF-technique with a 25 MeV deuteron beam from the AVF cyclotron of Tohoku University. DWBA analyses for bound and unbound states have been done to obtain spectroscopic information.

d. A Deeply-Bound Neutron-Hole States via the $^{116}Cd(d, t)^{115}Cd$ Reaction at $E_d = 33$ MeV$^+$ (T. Ishimatsu, T. Tohei, T. Nakagawa, J.I. Hirota, T. Kawamura and A. Sato)

$^+$A joint project with nuclear experimental group II.
See Nuclear Experimental Group II.

(II) INELASTIC ELECTRON SCATTERING

a. Giant Multipole Resonance in ^{154}Sm and ^{142}Nd (T. Tohei, J.I. Hirota, T. Saito, Y. Hozumi and Y. Torizuka)

Giant-resonance region in deformed ^{154}Sm have been studied by inelastic scattering in the effective momentum transfer range $0.52 \lesssim q_{eff} \lesssim 1.05$ fm^{-1}. Double bumps in the LEOR have been discussed in comparison with the (α, α') results at $E_\alpha = 65$ MeV.

In order to study the LEOR and HEOR strength distributions in a spherical nucleus the inelastic scattering from ^{142}Nd ($N = 82$) has been measured.

(III) POLARIZATION

a. The $^{13}C(\vec{p}, p')^{13}C$ Reaction at $E_p = 35$ MeV (H. Ohnuma, K. Furukawa, S. Hayakawa, T. Hasegawa, N. Hoshino, K. Ieki, N. Kabasawa, K. Miura, K. Nishimura, H. Orihara, T. Sueriro, T. Tohei and M. Yasue)

We have studied the $^{13}C(\vec{p}, p')^{13}C$ reaction at $E_p = 35$ MeV to look into the problem of the $1/2^- \rightarrow 1/2^+$ transition. The $(\vec{p}, p')$ experiment was done at INS, using a polarized proton beam from the AVF cyclotron and a magnetic spectrometer. The calculated (p, p') cross sections and analyzing powers for the states other than $1/2^+$ are also in good agreement with the data, provided

"effective charges" are introduced to some of the amplitudes.

On the contrary DWBA utterly fails to describe the (p, p') data for the $1/2^+$ state. The (p, p') data for the $1/2^+$ state show, similarly to those at higher energies, a large deviation from the prediction. Detailed analyses are in progress.

b. Excitation of the T = 1 and T = 0 0^- States in the $^{16}O(\vec{p}, p')$ Reaction
(H. Ohnuma, K. Furukawa, S. Hayakawa, T. Hasegawa, N. Hoshino, K. Ieki, N. Kabasawa, K. Miura, S.K. Nanda, K. Nishimura, H. Orihara, T. Suehiro, T. Tohei and M. Yasue)

We have studied the $^{16}O(\vec{p}, p')$ reaction at $E_p = 35$ MeV to obtain data directly comparable with the (p, n) data. The experiment was performed at INS, using a polarized proton beam from the AVF cyclotron and a magnetic spectrometer. The target was oxygen gas of natural abundance and at 0.5 – 1.0 atm. The differential cross sections and analyzing powers for the T = 1 and T = 0, 0^- states were measured. The DWBA results are compared with the data. Experiment is still under way, and large-angle data are currently being taken.

c. Proton-Deuteron Elastic Scattering with a L-Type Polarized Target
(G.J. Igo, M. Bleszynski, B. Aas, D. Adams, D. Lopiano, T. Nakagawa, Y. Ohashi, F. Sperisen, C. Whitten, S. Ishimoto, A. Masaike, K. Hasai, K. Twatani, S. Okumi, H. Fujisawa, M. Gazzaly, G. Pauletta, S. Greene, K. Jones, J. McClelland and N. Tanaka)

Spin observables associated with L, S and N-type polarized proton beams were measured to determine the scattering amplitude at 800 MeV by using HRS at LAMPF.

d. Examination of Spin-Orbit Coupling Force in the $(\vec{d}, {}^6Li)$ Reaction
(T. Yamaya, J.I. Hirota, K. Takimoto, S. Shimoura, A. Sakaguchi, M. Fukada, S. Kato, S. Kubono, M. Sugitani and T. Suehiro)

(IV) NUCLEAR PHYSICS BY HIGH-RESOLUTION (p, n) EXPERIMENTS

(H. Orihara, K. Furukawa, M. Kabasawa, T. Kawamura, Y. Takahashi, T. Niizeki, T. Nakagawa, K. Maeda, K. Miura, D. Dehnhard and H. Ohnuma)

In the course of exploration for spin-isospin modes of nuclear excitation and their relation to the π- and ρ-meson exchange interactions, we have studied;

(1) effective nucleon-nucleon interactions at low energies,
(2) properties of $\Delta S = 1$, $\Delta T = 1$ transitions leading to the residual states of 0^-, 1^+, 2^- ... 6^-,
(3) poralization of emitted neutrons following such an unnatural transition.

a. Observation of Quenching in Gamow-Teller Strength in the (p, n) Reaction on sd-Shell Nuclei

The $0^+ \to 1^+$ transition have been observed by the (p, n) reactions on ^{18}O, $^{20, 22}Ne$, $^{24, 26}Mg$, $^{28, 30}Si$ and $^{32, 34}S$, including major members of even-even nuclei in sd-shell as targets at $E_p = 35$ MeV. We have found a proportionality between B(GT) and the (p, n) cross sections. Furthermore, it was concluded that the $0^+ \to 1^+$ (p, n) cross sections are quenched as much as those in β-decay in the GR transitions presently observed.

b. Isovector "$\Delta J^\pi = 0^-$" Transition

Isovector $0^+ \to 0^-$ ($1/2^- \to 1/2^+$) transitions have been studied by the charge-exchange (p, n) reactions on $^{13, 14}C$ and ^{16}O at $E_p = 35$ MeV by means of the high-resolution neutron time-of-flight technique. Angular distributions of emitted neutrons were measured covering a wide range of the transfer momentum up to $q \sim 2.2$ fm^{-1}. DWBA analyses with the M3Y interaction give a resonable account of the observed cross sections at small angles ($\theta_{C.M.} \lesssim 60°$), where the tensor force plays a significant role. The enhancement of the $\Delta J^\pi = 0^-$ (p, n) cross section was observed at large momentum transfer. This evidence may suggest an effect of the pionic correlation in the nuclear medium.

c. T = 0 and T = 1 Stretched 6^- States in ^{26}Al observed by the ^{26}Mg(p, n)^{26}Al Reaction

The ^{26}Mg(p, n)^{26}Al reaction has been studied at $E_p = 35$ MeV. Three prominent peaks, observed at large angles, are interpreted due to stretched particle-hole states with T = 0 ($E_x = 6.9$ and 8.0 MeV) and T = 1 ($E_x = 9.3$ MeV). This is the first case, where stretched 6^- states are splitted into more than tree pieces in N > Z nuclei in the charge-exchange (p, n) reaction.

(V) HEAVY ION NUCLEAR PHYSICS

(T. Yamaya, O. Satoh, K. Kotajima, T. Shinozuka, M. Fujioka and K. Hasegawa)

a. Effect of a Spin-Orbit Coupling Force in $^{12}C + ^{28}Si$, $^{14}N + ^{28}Si$, and $^{16}O + ^{28}Si$ Elastic and Inelastic Scattering

b. Study of the Mott-Schwinger Polarization for Heavy Ion Scattering

c. Mono-Energy Neutron Source by a Heavy-Ion Collision

(VI) INSTRUMENTION

a. Recoil-Method Neutron Counter for Measurements of Polarization
(T. Suehiro, T. Yamaya, O. Satoh, K. Kotajima and S. Kato)

b. Development of Cathodes Lifetime for Heavy Ion Source at Tohoku Cyclotron
(T. Yamaya, O. Satoh, T. Shinozuka, K. Kotajima and M. Fujioka)

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2) Isovector "$\Delta J^{\pi} = 0^{-}$" transitions observed in the charge-exchange (p, n) reactions on $^{13,\ 14}C$ and ^{16}O, H. Orihara, in Neutron-Nucleus Collision A Probe of Nuclear Structure, edited by J. Rapaport et al., (A.I.P, 1984) p. 139.

3) Complete measurement of proton spin observables in proton-deuteron elastic scattering at 800 MeV, G.S. Weston, B. Aas, A. Azizi, E. Bleszynski, M. Bleszynski, G.J. Igo, D. Lopiano, T. Nakagawa, A. Rahbar, F. Sperisen, J. Wagner, A.T.M. Wang, C.A. Whitten Jr., W.D. Cornelius, K.W. Jones, H. Ohnuma and R.J. York, Int. Conf. on Particles and Nuclei, Heidelberg (1984).

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7) Target dependence of the (^{16}O, α) reaction at 145 MeV, T. Shimoura, N. Takahashi, T. Murakami, S. Shimoura, T. Fukuda, K. Katori, T. Yamaya and K. Nagatani, INS-RIKEN Int. Symp. on Heavy Ion Physics, Mt. Fuji, August 27-31, 1984.

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9) Four-nucleon pickup reaction on $12 \leq A \leq 94$ nuclei, K. Umeda, T. Yamaya, T. Suehiro, K. Takimoto, R. Wada, E. Takada, S. Shimoura, A. Sakaguchi, S. Murakami, M. Fukada and Y. Okuma, Nucl. Phys. A429 (1984), 88.

Doctor Thesis (March 1985)

D1) Mass dependence for the strength distribution of the LEOR in Sm isotopes, Jun-ichi Hirota.

Master Thesis (March 1985)

M1) Elastic scattering of heavy ions from ^{28}Si using the new data acquistion system, Osamu Satoh.